

ACOMA BASIN

The Acoma Basin has a complex structural history, having been deformed by three major periods of tectonism during Phanerozoic time: (1) Late Paleozoic formation of the ancestral Rockies during the Sevier orogeny, (2) Laramide thick and thin-skinned compressional tectonics, and (3) Cenozoic relaxation, extension, and volcanism.

The Sevier orogenic belt and Mogollan Highlands (Fig. P-12) constrained a subsiding foreland basin from Early Cretaceous through Late Paleocene time (Armstrong, 1968; Villien and Kligfield, 1986). The constrained basin, in combination with long-term eustatic sea level changes along the margin of the Cretaceous sea way, resulted in complex depositional patterns reflecting the interaction of tectonics and eustasy (Molenaar, 1983; Nummedal and Riley, 1991). The western shoreline of the epicontinental seaway advanced and retreated across New Mexico many times, leaving a record of intertonguing marine and non-marine sediments (Mellere, 1994). Higher-frequency cyclicity during transgressions in Middle Cenomanian through mid-Turonian time resulted in various tongues with interfingered members of the Dakota and Mancos shale (Fig. P-13; Landis et al., 1973; Molenaar, 1983; Hook, 1983). One of the most widespread of tongues in the Acoma Basin is the Late Cenomanian Twowells Tongue (Dane et al., 1971; Hook et al., 1980). The Twowells Tongue is underlain by the dark-gray Whitewater Arroyo Shale Tongue of the Mancos Shale and is overlain by the Graneros Shale Member of the Mancos Shale (Fig. P-12).

The Twowell Tongue of the Dakota Sandstone encompasses two depositional sequences, albeit incomplete in terms of systems tracts (Van Wagoner et al., 1988, 1990). The first is associated with the Whitewater Arroyo Shale and shoreface sediments, and the second includes estuarine cross-bedded sandstone lithosome, oyster beds,

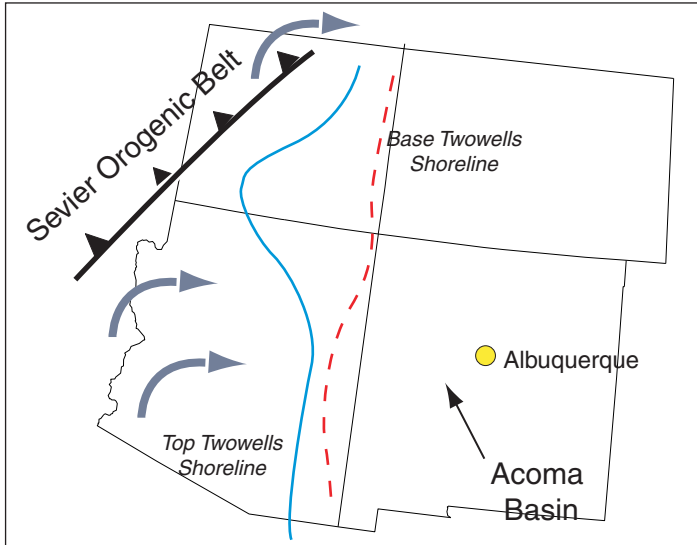


Figure P-12. Location of Pueblo Indian Reservations (esp. Acoma Pueblos) with indication of transport direction (arrows) of sediment that filled the Sevier foreland basins during the Cretaceous and, in particular, the Dakota Sandstone. The map also indicates the position of the shoreline at the base of the Twowells Tongue and the maximum transgression (modified after Mellere, 1994; Molenaar, 1983; and Eaton and Nations, 1991).

and black shale that caps the Twowells Tongue (Mellere, 1994). Figure P-14 illustrates a hypothetical paleogeographic reconstruction of the Twowells Tongue during highstand, lowstand, and transgressive phases.

PRODUCTION OVERVIEW

Oil and gas production in north central New Mexico was described in the 1995 *National Assessment of United States Oil and Gas Resources* (Gautier et al., 1996). All plays discussed in the "Play Summary Overview" combines the research from that publication along with other recent publications of interest to oil and gas in the Pueblo Indian Reservations. The following is a summary of the oil and gas plays within the (1) Albuquerque-Santa Fe Rift Province, (2) South-Central New Mexico Province, and (3) Raton Basin-Sierra Grande Uplift (Fig. P-15).

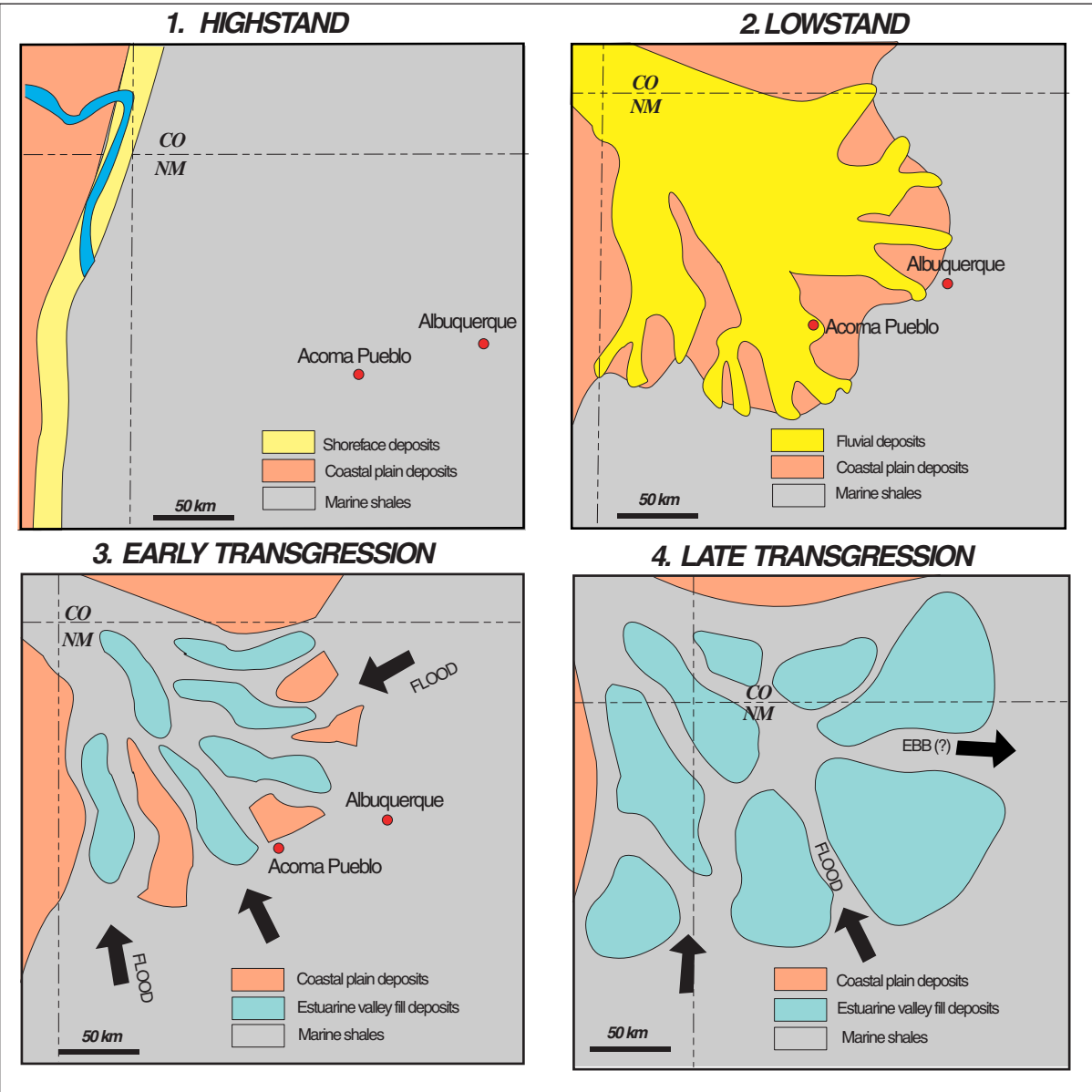


Figure P-14. Hypothetical paleographic reconstruction of the Twowells Tongue during (1) highstand, (2) lowstand, (3) early transgression and (4) late transgression (modified after Mellere, 1994).

Figure P-13. Schematic cross-section of the intertonguing relationships of the Dakota Sandstone and the Mancos Shale in the Acoma Basin (modified after Cobban and Hook, 1989).

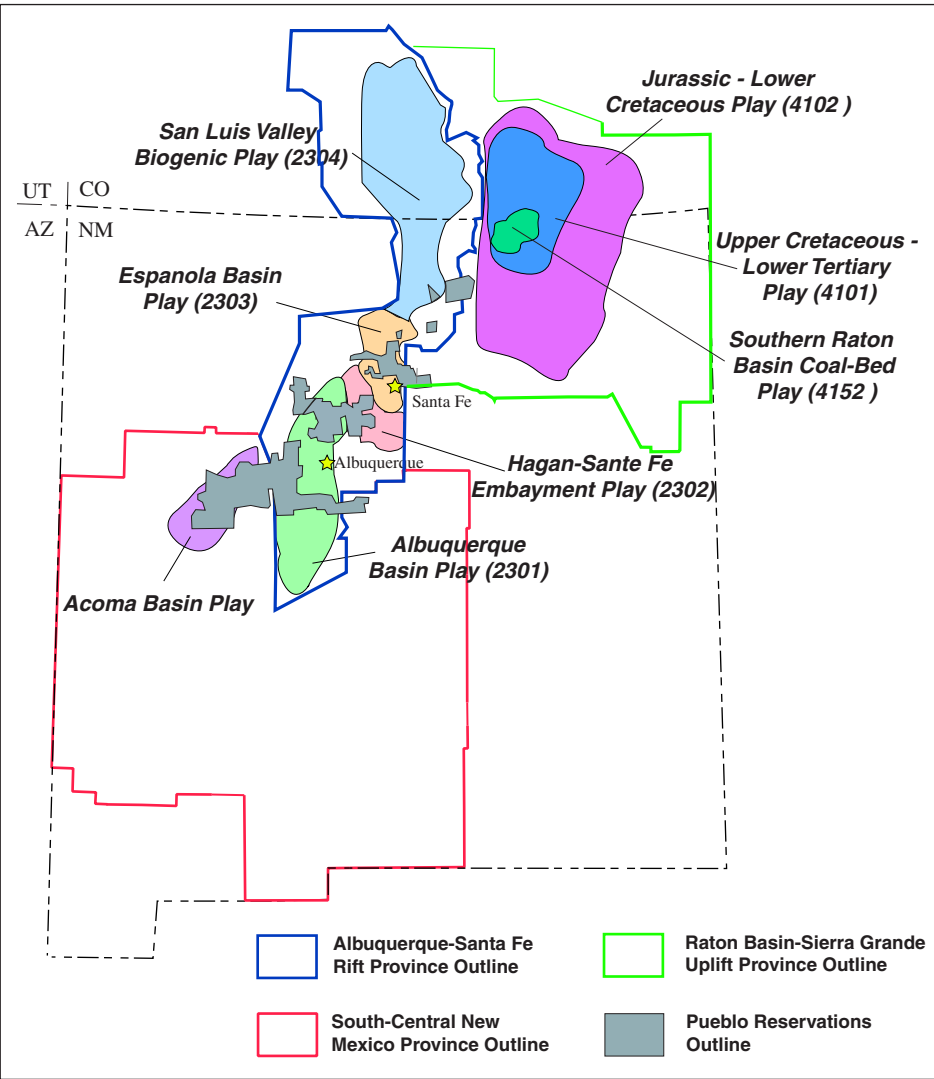
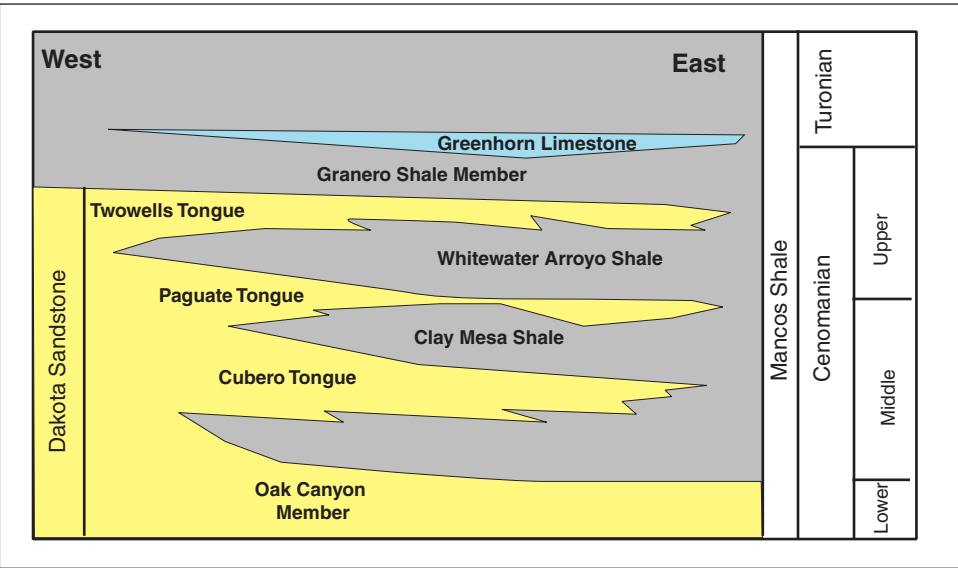


Figure P-15. Location of Pueblo Reservations with respect to the major geologic provinces and the respective hydrocarbon plays of northern New Mexico (modified after Gautier et al., 1996).

Play Summary

The United States Geology Survey (USGS) identifies several petroleum plays in the Albuquerque-Santa Fe Rift, Raton Basin-Sierra Grande Uplift, and South-Central New Mexico Provinces. Table 1 summarizes the petroleum plays relevant to the Pueblo Indian Reservations and describes the key characteristics of each field. The discussions that follow are limited to those plays with direct significance for future petroleum development in the Pueblo Indian Reservations.

Play Types

Conventional Plays - Discrete deposits, usually bounded by a downdip water contact, from which oil, gas, or NGL can be extracted using traditional development practices, including production at the surface from a well as a consequence of natural pressure within the subsurface reservoir, artificial lifting of oil from the reservoir to the surface, where applicable, and the maintenance of reservoir pressure by means of water or gas injection.

Unconventional Plays - A broad class of hydrocarbon deposits of a type (such as gas in "tight" sandstones, gas shales, and coal-bed gas) that historically has not been produced using traditional development practices. Such accumulations include most continuous-type deposits.

Reservation: Pueblo Indian Reservations		Geologic Province: Albuquerque-Santa Fe Rift Province, South-Central New Mexico Province, and the Raton Basin-Sierra Grande Uplift Province			Total Production (by Province-1996)		Undiscovered resources and numbers of fields are for Province-wide plays. No attempt has been made to estimate number of undiscovered fields within the Pueblo Indian Reservations.		
Province Area: Approximately 7,000, 39,900, and 18,800 square miles, respectively		Reservation Area: ?			Oil:	There has been no significant production in the three provinces.			
					Gas:				
					NGL:				
Play Type	USGS Designation	Description of Play	Oil or Gas	Known Accumulations	Undiscovered Accumulations > 1 MMBOE (med., mean)	Number of Undiscovered Accumulations (min., med., max., mean)	Play Probability (chance of success)	Drilling depths (min., max., med.)	
Albuquerque Basin Play	2301	Structural and Stratigraphic	Gas and Minor Oil	Gas (448,740 MMCFG) Oil (521,090 MBO)	20, 35.5 BCFG 3, 4.1 MMBO	Gas 2, 8, 30, 5.6 Oil 1, 2, 10, 1.7	0.49	6,000, 10,000, 8,000	
1									
Hagan-Santa Fe Embayment Play	2302	Structural and Stratigraphic	Oil	Gas (199,800 MMCFG) Oil (174,135 MBO)	2, 2.5 MMBO	Oil 1, 2, 4, 0.9	0.42	1,500, 7,500, 2,500	
2									
Espanola Basin Play	2303	Structural and Stratigraphic	Minor Oil	Gas (94.42 BCFG, est. mean) Oil (188.85 MMBO, est. mean)	Not Quantitatively Assessed	Not Quantitatively Assessed	0.06	Not Reported	
3									
San Luis Valley Biogenic Gas Play	2304	Stratigraphic; biogenic gas from lacustrine deposits	Minor Gas	Gas (7,000 BCFG)	Not Quantitatively Assessed	Not Quantitatively Assessed	0.03	Not Reported	
4									
Upper Cretaceous-Lower Tertiary Play	4101	Stratigraphic	Gas (methane)	Gas (7.8 BCFG, est. mean) Oil (7.8 MMBO, est. mean)	8, 12 BCFG	Gas 2, 4, 8, 2.8	0.64	4,000, 6,000, 5,000	
5									
Jurassic-Lower Cretaceous Play	4102	Stratigraphic	Minor Gas and Oil	Gas (62,100 MMCFG) Oil (22,8559 MBO)	Not Quantitatively Assessed	Not Quantitatively Assessed	0.09	Not Reported	
6									
Southern Raton Basin Play	4152	Coal-bed gas within fractured coal	Gas	Gas (8211.28 BCFG, est. mean)	571 BCFG (mean)	Not Reported	Not Reported	500, 1,400, 1,200	
7									
Acoma Basin Play	Not Designated	Stratigraphic	Gas and Minor Oil	Gas (59,518 MMCFG) Oil (53,700 MBO)	Not Reported	Not Reported	Not Reported	Not Reported	
8									

Table 1. Summary table of oil and gas plays that are located in or near the Pueblo Reservations.

Conventional play type

Unconventional/Hypothetical play type

Albuquerque-Santa Fe Province

This province is part of the Rio Grande Rift system and consists of segmented or offset basins that formed as a result of middle Tertiary to Quaternary rifting. The province extends from Socorro, New Mexico, northward 280 miles through the San Luis Valley in Colorado (Fig. P-16). The east-west width of the province ranges from 15 to 65 miles and the eastern and western boundaries are mostly uplifted mountain blocks exposing Precambrian and Mesozoic rocks generally dipping away from the rifted basins. The primary hydrocarbon objectives in the province are pre-rift Cretaceous and older strata, which in most of the province are covered by continental Tertiary-Quaternary fill. More than 20,000 feet of fill has masked the Laramide and older structures, thereby necessitating seismic data to delineate structure.

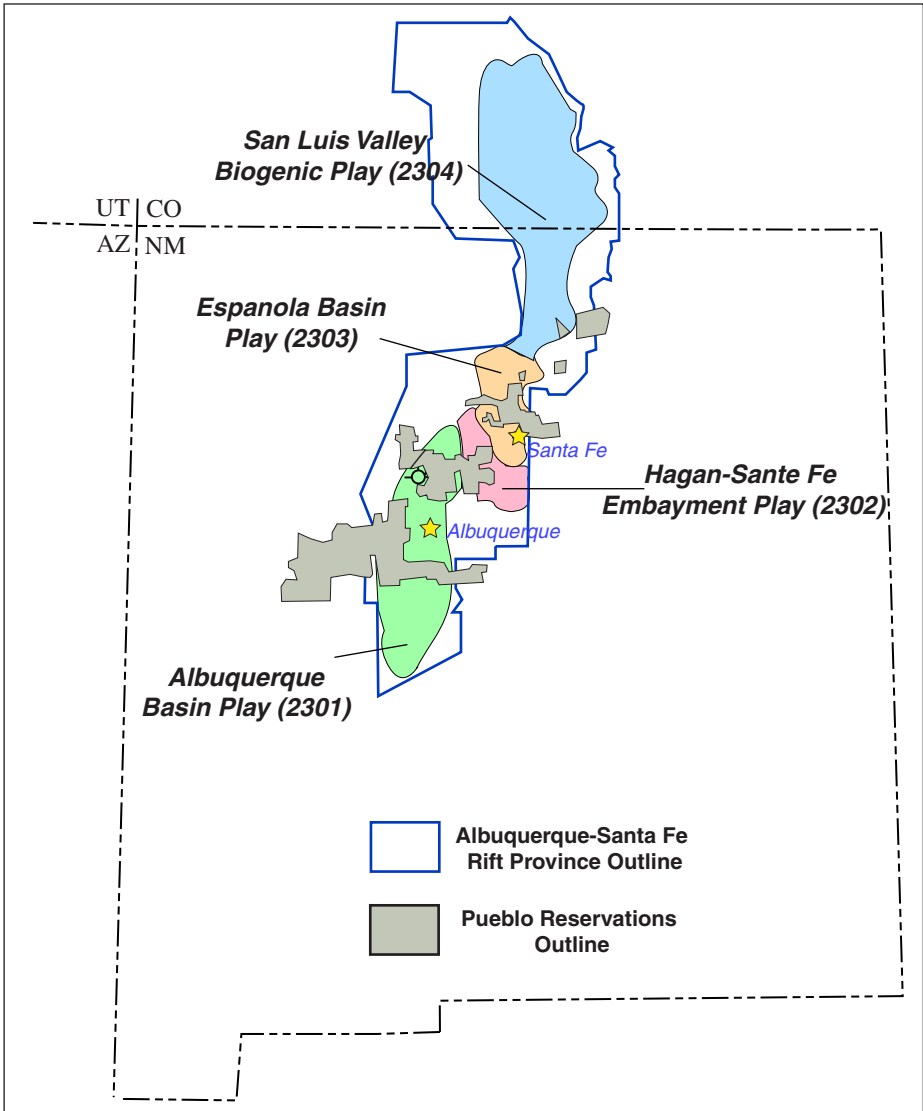


Figure P-16. Outline of Pueblo Reservations with respect to the Albuquerque-Santa Fe Rift Province. The Albuquerque Basin Play (2301), Hagan-Santa Fe Embayment Play (2302), Espanola Basin (2303), and the San Luis Valley Biogenic Play (2304) are depicted (modified after Gautier et al., 1996).

About 120 wells have been drilled in the province (Fig. P-17), but only about 50 wells penetrated Cretaceous or older rocks. Most of these latter wells were drilled in the 1970's and early 1980's. There is no production in the province, although there was marginal oil production for a short time from two wells in different areas of the province. Recent exploration has been minimal in the basin, with the exception of dry holes in the northwestern part of the province (Molenaar, 1993). Based on expected reservoirs, reservoir depth, type of hydrocarbon expected, drilling history, and geography, four relevant and hypothetical plays were identified by the USGS. These are the Albuquerque Basin Play (2301), Hagan-Santa Fe Embayment Play (2302), Espanola Basin Play (2303), and the San Luis Valley Biogenic Gas Play (2304). The plays of interest to the Pueblo Reservations are discussed in the Play Summary Overview.

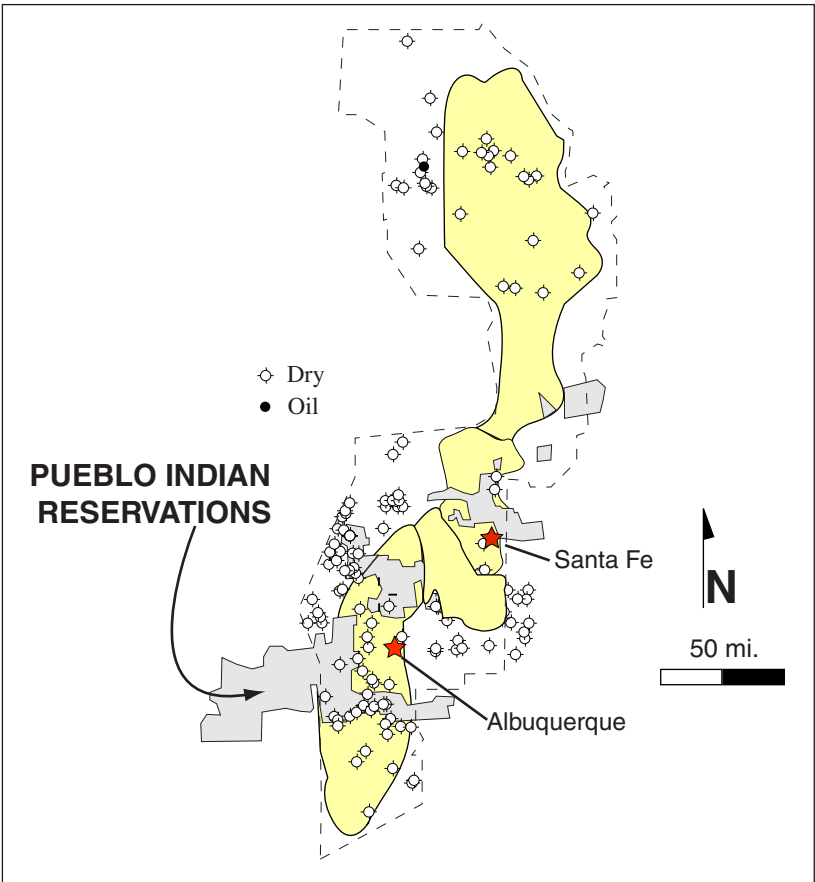


Figure P-17. Outline of Albuquerque-Santa Fe Rift Geologic Province with exploration wells from 1900-1993 depicted. The Albuquerque, Espanola and San Luis Basins are highlighted in addition to the Hagan-Santa Fe Embayment (modified after

Albuquerque Basin Play (USGS 2301)

General Characteristics

This is a hypothetical structural play related to down-dropped blocks of Mesozoic and Paleozoic rocks that have been buried to a sufficient depth for the generation of hydrocarbons, or in areas where structures are along migration paths of downdip-generated hydrocarbons (Black, 1982). The Albuquerque Basin Play is in the large, generally flat or low-relief area of the Albuquerque Trough (Fig. P-18) and is bounded on the east by the Sandia, Manzano, and Los Pinos Mountains, which are composed of Paleozoic and older rocks. The west side is bounded by the Puerco Platform, composed of Cretaceous rocks, and the Lucero Uplift and Ladrone Mountains, both of which consist of Paleozoic and older rocks. The northern boundary is a volcanic-covered area where the rift is offset to the east and the southern boundary is marked by the converging of the flanking up lifts in the vicinity of Socorro.

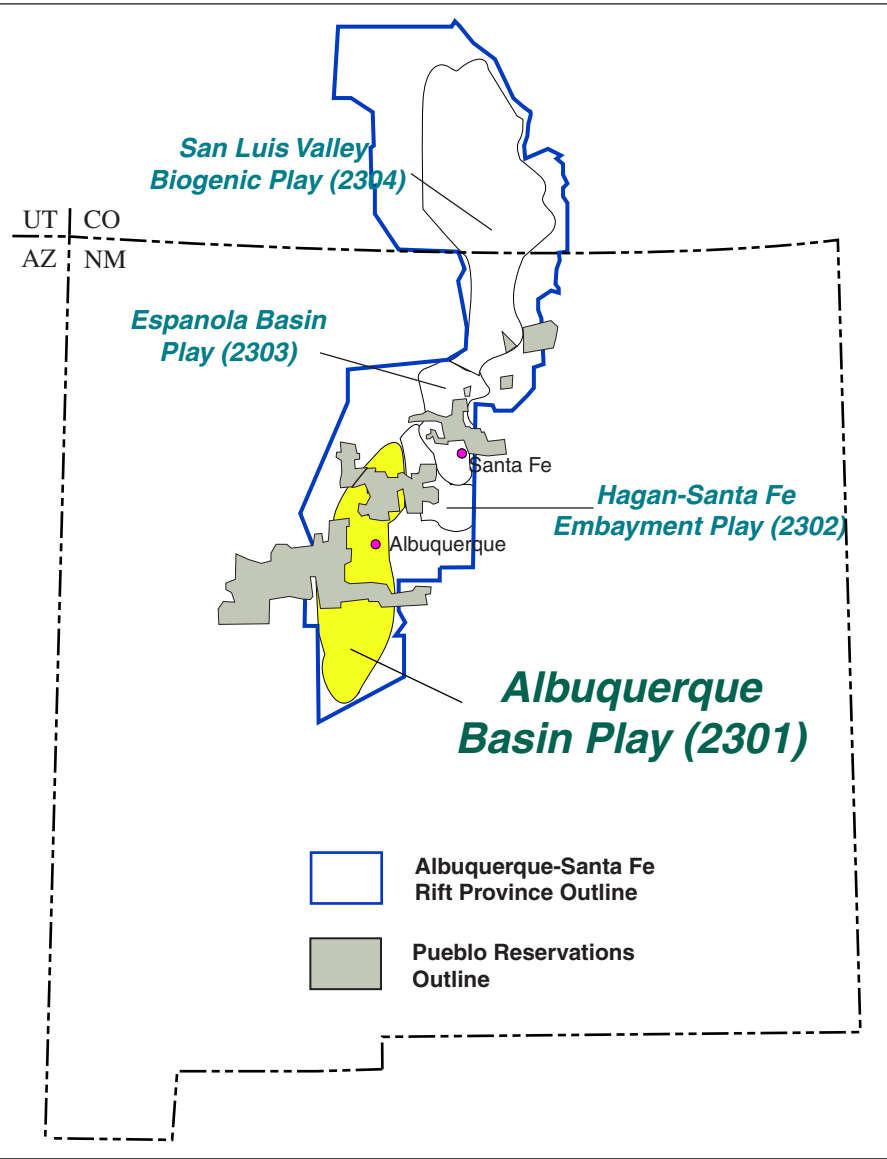
Reservoirs: The primary objectives of this play are coastal and marine Cretaceous sandstones that are along depositional strike with the San Juan Basin where these rocks are major producers of oil and gas. Secondary objectives are the Jurassic Entrada Sandstone and Paleozoic shelf sandstones and carbonates. All these potential reservoirs range in thickness, but are generally less than 100 feet thick. Recoveries on drill-stem and production tests of Cretaceous sandstones in wells in the play area indicate low permeabilities for these potential reservoirs (Molenaar, 1993).

Source rocks: Oil-prone source rocks are in the basal marine part of the Cretaceous section (Green

Figure P-18. Location of Albuquerque Basin Play (2301), with respect to the Pueblo Reservations (modified after Gautier et al., 1996).

horn interval). In the northern part of the play area, the middle part of the Mancos Shale is the major source rock. Good gas-prone, Type III source rocks are in Cretaceous carbonaceous shales and coals. The maturation ranges from immature to marginally mature along the shallower basin margins to overmature or gas-prone in the deeper parts. Most of the play is considered a gas play because of the predominance of gas shows in the drilled wells, the gas-prone nature of most of the source rocks, and the generally high maturations.

Timing and migration: Data are lacking on the timing and migration of hydrocarbons, but it seems likely that the amount of burial by Tertiary sediments and the degree of tilting of individual fault blocks was a controlling factor, thereby indicating recent hydrocarbon migration.



Traps: Although the structure of underlying rocks is obscured by the late Tertiary fill, normal faulting seems to be a predominant structural feature of the Albuquerque Basin (Figs. P-4 and P-19). At least three of the nine Cretaceous test wells encountered normal faults that cut out significant parts of the section (Fig. P-20). Traps are anticipated closures within different fault blocks, and many probably would be fault traps. Drilling depths to the Dakota Sandstone are 6,000 to 20,000 feet, and the size of the possible traps are unknown. Seals are dependent on fault seals and overlying impermeable shales, either within the Cretaceous section or overlying Tertiary fill. The abundance of gas shows in the Tertiary continental section, which probably was sourced from Cretaceous rocks, suggests that sealing of Cretaceous or older reservoirs may be a problem.

Exploration status: Of 46 tests in the play area, only nine penetrated the Cretaceous section (Table 2) and four penetrated all or parts of the Paleozoic section. The Tertiary and Quaternary fill, which is greater than 20,000 feet in some places, has masked Laramide and older structures, thereby necessitating seismic data to delineate structure. Published data on pre-Tertiary structure are not available, but Shell Oil Company conducted seismic surveys throughout the basin in the 1970's and drilled, or caused to be drilled, nine deep test wells (Fig. P-20). The seismic data must have been difficult to interpret in places, judging by the differences between the prognosticated formational depths and the actual drilled depths. Gas and some oil shows were reported in Cretaceous rocks (Fig. P-21). Unsuccessful attempts were made in one well to complete for gas production in the Shell farmout (Molenaar, 1987).

Resource potential: In summary, the Albuquerque Basin Play covers a large area and has the potential for large amounts of hydrocarbons, probably gas. Little is known about the subsurface structure. Seismic data collected in the recent past seem to have been of only moderate quality, necessitating additional seismic surveys because the few deep tests indicate that large normal faults are present and may control hydrocarbon occurrence.

Well No. and Name	Location	Completion Date	Total Depth (ft)
Shell SFP No. 1	18-13N-3E	6-19-72	11,045
Shell Laguna-Wilson Trust No. 1	8-9N-1W	9-21-72	11,115
Shell SFP No. 2	29-6N-1W	3-29-74	14,305
Shell Isleta No. 1	7-7N-2E	10-25-74	16,346
Shell SFP No. 3	28-13N-1E	4-19-76	10,276
TransOcean Isleta No. 1	8-8N-3E	10-4-78	10,378
Shell Isleta No. 2	16-8N-2E	11-23-79	21,266
Shell West Mesa Fed. No. 1	24-11N-1E	12-30-80	19,375

Table 2. Summary table of eight deep test wells in Albuquerque Basin (modified after Molenaar, 1987).

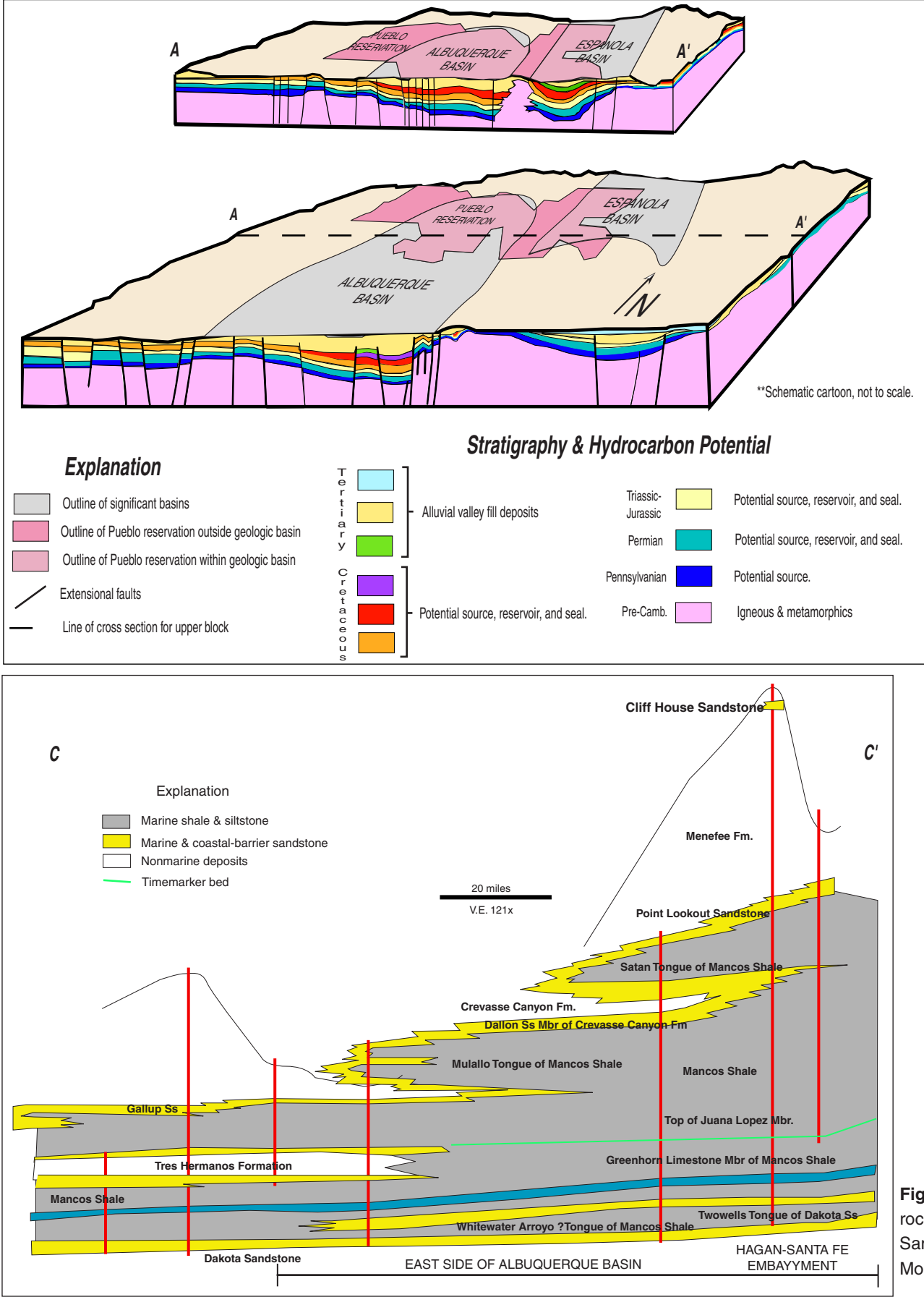


Figure P-19. Block diagram depicting schematic structure across the Albuquerque and Espanola Basins (modified after Black, 1982).

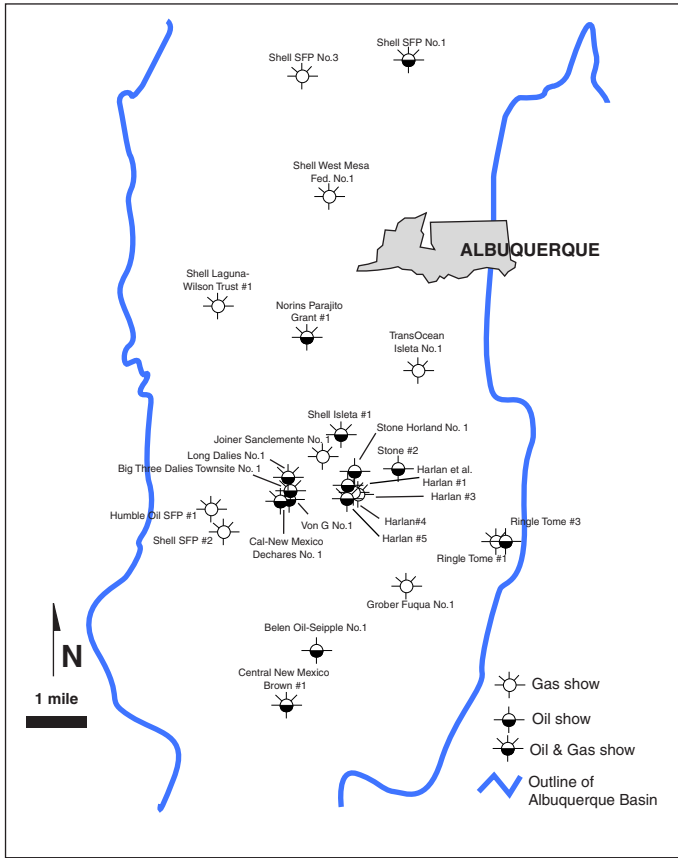


Figure P-21. Test wells that had shows of oil and gas in Albuquerque Basin (modified after Black, 1982).

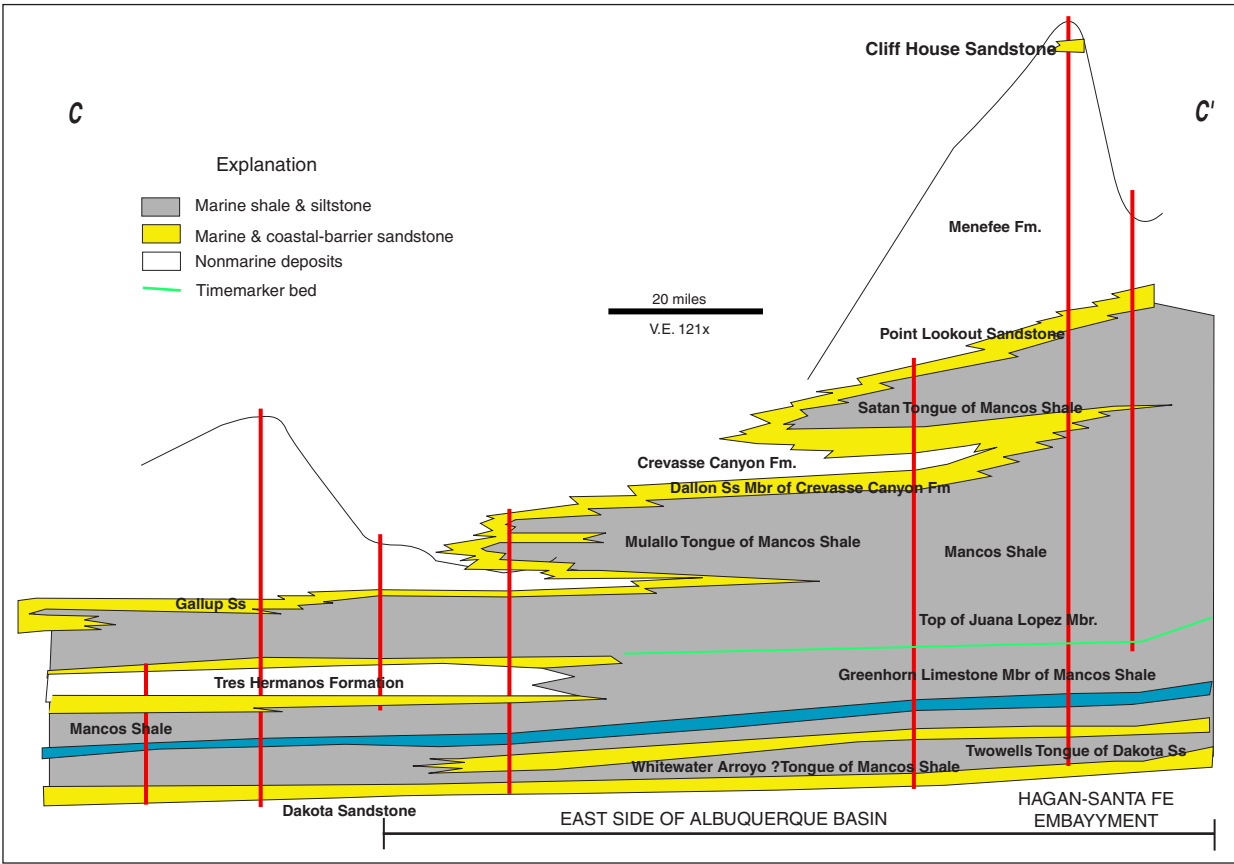


Figure P-20. Stratigraphic cross-section C-C' of Cretaceous rocks along the east side of the Albuquerque Basin into the Santa Fe Embayment (Fig. 7; cross-section 3) (modified after Molenaar, 1983).

(USGS 2302)

The Hagan-Santa Fe Embayment is in the southern part of the Espanola Basin, but because of the different play attributes, this hypothetical play is split off from the Espanola Basin Play and is considered separately (Fig. P-22). The play area is tear-drop shaped and about 25 miles in diameter. It is bound on the west by the northern volcanic-covered end of the Albuquerque Basin, on the east by the southern plunge of the Sangre de Cristo Mountains, and on the south by the Sandia Mountains and their broad eastern flank. To the north, the play is separated from the Espanola Basin along the line of truncation of Cretaceous rocks, which is controlled by wells in one area.

Source rocks: The primary oil-source rocks are of moderate quality and are in the lower part of the Mancos Shale and, where preserved, the Niobrara-equivalent within the Mancos. Shales at the base of the Todilto Limestone are also potential source rocks. In addition, carbonaceous shales in the Dakota and above the Mancos Shale are potential gas source rocks. All of these rocks are mostly in the oil-generating range, although maturation levels range widely because of Oligocene intrusion of volcanics in the area (Molenaar, 1987).

Traps: Traps of probable small to moderate size are both structural and stratigraphic, the latter in the case of lenticular Semilla and Tocito Sandstone Members (Fig. P-23). Seals would be overlying Mancos Shale for Cretaceous reservoirs, Todilto Anhydrite for the Entrada Sandstone, and interbedded shales for the Pennsylvanian carbonate reservoirs.

Resource potential: In summary, the Hagan-Santa Fe Embayment Play covers a relatively small area, and the individual trap sizes are probably small. Although gas has been encountered, the main potential is oil. Shallow drilling depths along with outcrop and well control allow for a better understanding of the geologic structure when compared to the Albuquerque Basin.

